Estimation of the emission sources based on the relationship between atmospheric O2 and CO2 variations at Hateruma and Ochi-ishi

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Short-term variations in atmospheric CO_2 concentration are usually associated with the inversely correlated changes in the O_2 concentration. This is because the fact that the exchange between CO_2 and O_2 occurs during most source processes including fossil fuel burning and land biotic respiration/photosynthesis. The exchange ratios of O_2 to CO_2 depend on the elemental compositions of the organic materials produced or consumed during the individual source processes. For example, the exchange ratio is -1.1 for the land biotic processes, -1.95 for natural gas burning, -1.44 for gasoline burning, and -1.17 for coal burning. Therefore, slopes of the correlation plots between O_2 and CO_2 concentrations during the short-term event (D_O_2/D_CO_2 ratio) could give some information on the CO_2 sources process.

In-situ measurements of atmospheric O_2 and CO_2 concentrations have been conducted at Hateruma Island (HAT, Lat. 24.3N, Long. 123.49E) and Cape Ochi-ishi (COI, Lat. 43.1N, Long. 145.3E). These data often showed large variations with the synoptic-scale durations and there are inverse correlations between O_2 and CO_2 variations. The short-term events have been extracted from the time series by visual inspection, and the D_O_2/D_CO_2 ratios for the events have been calculated. Based on backward trajectory calculation, we have classified the event by the source countries (China, Japan, Korea, and Taiwan) that mostly influenced the events.

Using the data observed at Hateruma during the period from October 2006 to August 2008, we have found 50 events, including 22 China, 12 Japan, and 9 Korea events. The average D_O_2/D_CO_2 ratios for China, Korea, and Japan events are -1.20+/-0.02, -1.40+/-0.05, and -1.45+/-0.06, respectively. Because these events occurred during late fall-early spring (November-April), the contribution of the biological emissions to the observed O_2 and CO_2 variations are relatively small. Therefore, the resulted D_O_2/D_CO_2 ratios suggest that the fractional contribution of coal consumption to the total fossil fuel consumption is larger for China than for Korea and Japan. Actually, the O_2:CO_2 exchange ratios for the fossil fuel emissions from the individual countries, calculated from national fossil fuel emission inventories from CDIA data, show good agreements with the observed D_O_2/D_CO_2 ratios. On the other hand, the average of D_O_2/D_CO_2 ratios for the 76 short-term events in the observations at COI (March 2005-December 2007) is -1.14+/-0.03. Because most of the events occurred during summer-early fall (June-October), the biological emissions probably contributed to the observed CO_2 and O_2 variations at COI.